

REMARKS

Claims 1-47 were submitted with the application as filed. Claims 48-66 were submitted in a preliminary amendment mailed on August 3, 2004. Claims 67-76 were submitted in a second preliminary amendment mailed on July 28, 2005.

Claims 1-76 are now pending. Claims 1-76 have been examined. Claims 1-32 and 34-76 have been rejected. Claim 33 was objected to but would be allowable if written in independent form, including all limitations from its independent and intervening claims. Applicants appreciate this indication of allowability.

Applicants appreciate the courtesy of the interviews extended by the Examiner and his supervisor to Applicants' undersigned representative on May 3, 2006 and May 4, 2006. During these interviews the Uzoh reference was discussed. Specifically, the relevance of the Uzoh reference to claims 1 and 38 was discussed. These claims recite "etching metal from the substrate . . . to a position below an upper level of exposed dielectric in the layer" During the interviews, the undersigned emphasized that (1) Applicants do not intend to cover CMP processes in this etching operation and (2) the Uzoh reference does not show "*etching* metal from the substrate . . . to a position below an upper level of exposed dielectric in the layer." Any metal not in existence in the trench or via shown in Uzoh's Figure 3Biib (below an exposed region) results from conformal deposition of the metal, not from etching. The Examiner's supervisor suggested that nevertheless Uzoh's CMP process might result in some CMP slurry finding its way into the conformal recesses shown in Figure 3Biib to undesirably etch some small amount of metal in these recesses. The Examiner's supervisor also suggested that any CMP process that clears metal to a level of an exposed dielectric layer might unintentionally remove some small amount of metal in vias and trenches to a level below the exposed dielectric.

Independent claims 1 and 38 have been amended to recite "wet etching metal from the substrate from a position above or coplanar with an upper level of dielectric to a position below the upper level of exposed dielectric in the layer by contacting the substrate with a wet etching solution". Independent claims 43, 48, 57, and 67 have been amended to recite "contacting the substrate with a wet etching solution". Support for these amendments is found at page 8, fourth paragraph; page 10, second paragraph; and claim 7. Claim 7 has been canceled. Claims 8, 16-18, and 24 were amended to depend from claim 1. Claim 25 has been amended to be in independent form. Other claims have been amended to make minor clerical changes.

All rejected claims were rejected based on at least one of US Patent No. 6,355,153 issued to Uzoh et al., US Patent No. 6,692,548 issued to Ma et al., and US Patent Application Publication No. 2001/0038448 issued to Jun et al. Only the rejections of dependent claims 25-27 and 35 involved additional references. Claims 25-27 were rejected over a combination of Uzoh

et al. and US Patent No. 6,329,284 issued to Maekawa. Claim 35 was rejected over a combination of Uzoh et al. and US Patent No. 6,716,753 to Shue et al.

As explained below the pending claims are patentable over these references. Of note, both Uzoh et al. and Ma et al. disclose polishing and planarization using abrasive slurries and pad-based techniques such as CMP apparatus.

Rejections based on Uzoh et al.

In the rejection of independent claims 1 and 38, the Office points to Uzoh et al., column 7, lines 54-56 and fig. 3Biib as disclosing etching metal from the substrate to a position below an upper level of the exposed dielectric layer.

The Applicants point to several important distinctions between the planarization method described by Uzoh et al. and the etching method disclosed in the Applicants' specification and recited in claims 1 and 38.

First and foremost, the Applicants are claiming a wet etching process. It is well understood in the art that wet etching is fundamentally different from pad-based planarization and polishing techniques, such as CMP. In the wet etching method the surface of the substrate is contacted with a *wet etching solution*, capable of deep etching without being abrasive. In the pad-based planarization techniques, such as CMP, the abrasive pad and abrasive *slurries* are required for removal of material from the surface of a substrate exposed to the pad. These pad-based techniques, as understood in the art, are virtually limited to planarization and polishing due to the nature of the pad – substrate contact. Hence, wet etching employs different means and accomplishes different goals than pad-based techniques. Wet etching, as understood in the art, does not encompass the use of any pad-based abrasives or abrasive slurries. An MIT lecture on etching techniques presented in the Appendix explains that CMP and wet etching are distinct types of removal processes employed in semiconductor fabrication. It is clearly stated that wet etching is a chemical process only (slide 2) while CMP combines chemical and physical components of etching (slide 22). See the Appendix below taken from http://hackman.mit.edu/6152J/SP_2004/lectures/sp_2005_Lecture12.pdf

Uzoh et al. is referring to planarization and pad-based polishing techniques, including CMP, while describing Figure 3Biib (column 7, lines 53-65). The Applicants are referring to wet etching in the specification by employing “solution” and “wet solution” language and by clearly distinguishing CMP as a different separate process which can be optionally performed before the actual wet etch step (page 8, fourth paragraph). Claims 1 and 38 as amended now recite “wet

etching metal from the substrate ... by contacting the substrate with a wet etching solution” and do not encompass the pad-based techniques referred to by Uzoh et al.

Secondly, the Applicants note again that the recesses shown in Figure 3Biib were already present in the structure 3Biia. The Applicants acknowledge the position of the Office, stated in the above-referenced telephone interview, that some small amount of the metal in the recesses shown in Figure 3Biia possibly could be etched out during the planarization of the field regions leading to the structure shown in Figure 3Biib. The Applicants do not believe there is support for this statement in the Uzoh reference. However, the Applicants have amended claims 1 and 38 to recite “wet etching metal from the substrate *from a position above or coplanar with an upper level of dielectric*”. Uzoh et al. does not disclose creating a recess in the substrate. Therefore, claims 1 and 38 are patentable over Uzoh.

Lastly, both the original and amended claims 1 and 38 recite “etching metal ... to a position below the level of *exposed dielectric*”. Uzoh et al. does not disclose this limitation at all. Figure 3Biib presents the substrate with an exposed layer 4. Layer 4 is not a dielectric but is a diffusion barrier layer. As stated in column 1, lines 35 – 41 of the Uzoh patent, this layer may be composed of Ta, Ti, W, TiW, TiN and the like. It is well understood in the art that this type of diffusion barrier layer has considerable conductivity and is by no means a “dielectric.”

In view of these distinctions, it is respectfully submitted that the cited portions of Uzoh et al. fail to teach or reasonably suggest “wet etching metal from the substrate from a position above or coplanar with an upper level of dielectric to a position below the upper level of exposed dielectric in the layer by contacting the substrate with a wet etching solution.” Withdrawal of the 102 rejections based on Uzoh et al. is therefore respectfully requested. This includes not only independent claims 1 and 38, but the dependent claims 2-9, 14-24, 28-32, 34, 36-37, and 39-42 as well.

Regarding claim 25 which is presently amended to an independent claim, the above discussion regarding claims 1 and 38 applies in so far as it is not directed to the wet etching features of the claims. The relevant discussion pointed out that neither Uzoh nor Maekawa teaches the limitation of “etching metal from the substrate from a position above or coplanar with an upper level of dielectric to a position below the upper level of exposed dielectric in the layer by contacting the substrate with a wet etching solution” In addition, Maekawa discloses exposing copper to an oxidizing gas atmosphere containing oxygen, or reducing gas atmosphere containing hydrogen, or an inert gas atmosphere (column 7, 3-13). All of these manipulations are employed in the high-pressure process of burying the conductor in a layer of dielectric. No material is removed in this process, there is no context of etching in this disclosure, and, therefore, there is no suggestion to one skilled in the art to combine this process with etching. Withdrawal of the 103 rejection based on Uzoh et al. in view of Maekawa et al. is therefore

respectfully requested. This includes not only independent claims 25 but the dependent claims 26-27 as well.

Applicants note that claims 10-13 and 35 were rejected over various combinations of references that included Uzoh et al. The other cited references (Ma et al., and Shue et al.) also fail to overcome the deficiencies above. Shue does not show “wet etching metal from the substrate from a position above or coplanar with an upper level of dielectric to a position below the upper level of exposed dielectric in the layer by contacting the substrate with a wet etching solution.” Ma et al. fails to disclose forming capping layers in the manner claimed and has little in common with Uzoh et al. to suggest combining the references in a manner that would suggest the methods of claims 1 and 38. As the combinations of cited references fail to suggest the claimed invention, it is respectfully submitted that claims 10-13 and 35 are patentable over the cited art. Withdrawal of the rejection is respectfully requested.

Rejections based on Ma et al. in view of Jun et al.

Claims 43-76 were rejected as obvious over Ma et al. in view of Jun et al. According to the Office, the operation of etching metal from the substrate to a position below an upper level of exposed dielectric (claim 43) is disclosed at column 8, lines 55-60 and column 9, lines 15-37. The description appearing at these locations pertains to the composition of a CMP slurry. In fact, the entire specification of Ma et al. pertains to CMP and CMP slurries. As it was discussed above, CMP is a pad-based technique and as such it heavily relies on the abrasive properties of the pad and of the slurry for its effectiveness. The Applicants’ invention, however, relies on the use of wet etching, which is known in the art to be distinct from CMP and to exclude the use of abrasive slurries and abrasive-coated pads. The independent claims 43, 57, 48 and 67 as amended recite “contacting the substrate with *a wet etching* solution”. None of the methods described in the Ma et al. patent encompasses wet etching, with all of the described processes relying on the mechanical impact of the abrasives on the substrate surface. The Office states in the Response to Arguments that in column 7, lines 1-6, Ma et al discloses a slurry containing an activating agent that etches the oxidized copper. The Office implies that the presence of such an activator in the slurry would anticipate the limitation of “contacting the metal with an etching solution”. The Applicants failed to find such a disclosure in the given paragraph which is concerned with the dishing problem.

Ma does, in fact, disclose slurries which may contain various activating, passivating or cleaning agents in column 9, lines 1 – 35. Some of these agents may in fact solubilize oxidized copper. The Applicants, however, respectfully dispute that Ma describes a wet etching process. Wet etching as is conventionally understood is a non-mechanical, non-pad based technology. It

is understood in the art, that although CMP slurries are chemically reactive and do solubilize the material to be removed, the mechanical component of CMP is indispensable for the effectiveness of the process. This stems primarily from the fact that the reaction products or the oxidized material itself need to be mechanically removed by a contact with abrasive pads or slurries before the reaction can proceed further. The Chemical Mechanical Polishing as its name suggests is an integrated process, relying on the interplay between chemical reactions and mechanical material removal. Therefore CMP cannot be regarded as a process anticipating wet etching, neither in general nor in the case of the pending claims, which do not encompass mechanical removal techniques. Amended claims 43, 57, 48 and 67 recite “contacting the substrate with a *wet etching* solution” and are patentable over CMP methods regardless of the reactivity of individual components of the CMP slurry.

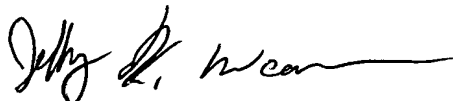
Applicants also note that Ma et al. fails to teach the limitation of claim 43 of “etching metal from the substrate to a position below an upper level of *exposed dielectric*”. The exposed layer 21 in Figure 3 of the Ma et al. patent refers to the diffusion barrier layer (column 6, lines 50-51). This barrier layer is composed not of a dielectric (layer 22 in Figure 3) but of materials commonly used as barrier materials, such as tungsten nitride, tantalum, tantalum nitride, titanium nitride and the like (column 4, lines 63-67). This type of barrier is known in the art to have substantial conductivity.

Withdrawal of the 103 rejections based on Ma et al. is respectfully requested. This includes not only independent claims 43, 48, 57, and 67, but the dependent claims 44-47, 49-56, 58-66, and 68-76 as well.

Conclusion

Applicants believe that all pending claims are allowable and respectfully request a Notice of Allowance for this application from the Examiner. Should the Examiner believe that a telephone conference would expedite the prosecution of this application, the undersigned can be reached at the telephone number set out below.

Respectfully submitted,
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